'99 Energy

An Energy Efficiency Workshop & Exposition

Orlando, Florida August 23 - 25, 1999

Laboratory Case Study

The Louis Stokes Laboratories

(Building 50)
National Institutes of Health

Presented by Frank Kutlak, RA

Office of Research Services

Division of Engineering Services

Design, Construction & Alterations Branch

Office of Research Services

Building A Better NIH

Design, Construction and Alterations Branch | *Division of Engineering Services* | *Office of Research Services*

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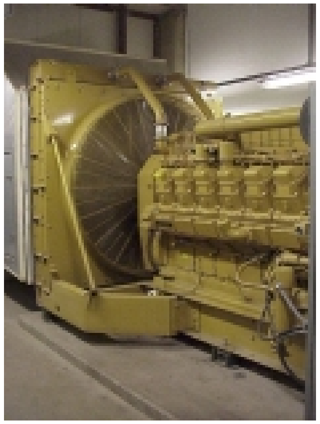
Research Laboratories Design

- Research laboratories are energy demanding for a variety of reasons:
  - Safety requirement for once through air
  - Large numbers of containment and exhaust devices
  - Large amount of heat generating equipment
  - 24 hour access requirement by Scientists
  - Irreplaceable experiments require fail safe redundant back up systems, and UPS or emergency power



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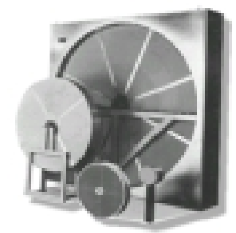
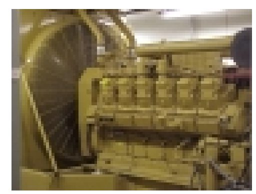
Energy Concerns in the Design of Research Labs

- **Comply with Executive Order 13123 - *"Greening the Government Through Efficient Energy Management*", issued June 8, 1999 which requires the**
- **Federal Government to improve it's energy management practices.**
  - **Sec. 203 specifically requires that Laboratory Facilities reduce energy consumption by 20% by 2005 and 25% by 2010, relative to 1990**
- **Architectural**
  - **Overall Concern with Energy Issues in Design of Facility**
  - **Building Layout, Mass and Orientation**
  - **Thermal Envelope - Elements of Enclosure / Exterior Skin**

- **Mechanical**
  - **Building Supply and Exhaust Systems**
  - **Containment Devices (primarily fume hoods)**
  - **Energy Recovery Systems**



- **Electrical**
  - **Power Design Levels**
  - **Lighting - Light Levels, Fixture Types and Controls**
  - **Emergency Power or Uninterruptable Power Supply (UPS)**



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Architectural Concerns in the Design of Energy Efficient Research Labs

- **Comply with Executive Order 13123 - *"Greening the Government Through Efficient Energy Management*", issued June 8, 1999 which requires the Federal Government to improve it's energy management practices.**
- **Overall Concerns with Energy Issues in the Design of the Facility**
- **Maximum feasible and practical energy efficiency should be a prime design program requirement and one of the major goals of the design**
  - **square footage and budget must be assigned to energy efficient design features and the building design must accommodate them**
- **Building Layout, Mass and Orientation should enhance energy efficiency**
- **Elements of Enclosure / Exterior Skin should be energy efficient**
  - **Design should provide appropriate thermal resistance**
  - **Design should provide effective moisture resistance**
  - **Window glazing should be Low "E" Glass - low solar transmission**

2" Rigid Insulation

Waterproofing and Flashing

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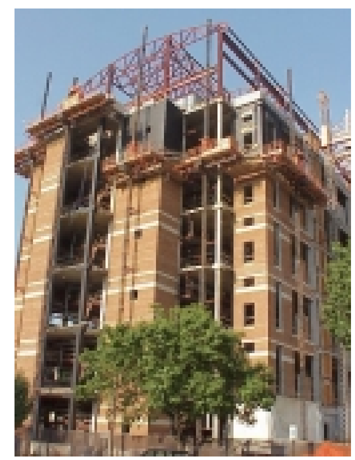
Building 50 Design Features

- 290,000 gross square foot
- 60% efficient (net to gross ratio)
- Open Plan Labs grouped in “neighborhoods” with systems furniture workstations at large windows
- Modified Interstitial Mechanical Level Concept
- Mostly BL2 labs but contains a BL3 Suite
- Animal Vivarium with BL3 and Quarant areas
- Major EM Suite and NMR Lab Facility
- Central Conference Room Suite
- ity Card Access Control
- ension Concrete Structural System
- Multiple Energy Conservation Devices



HLM Design

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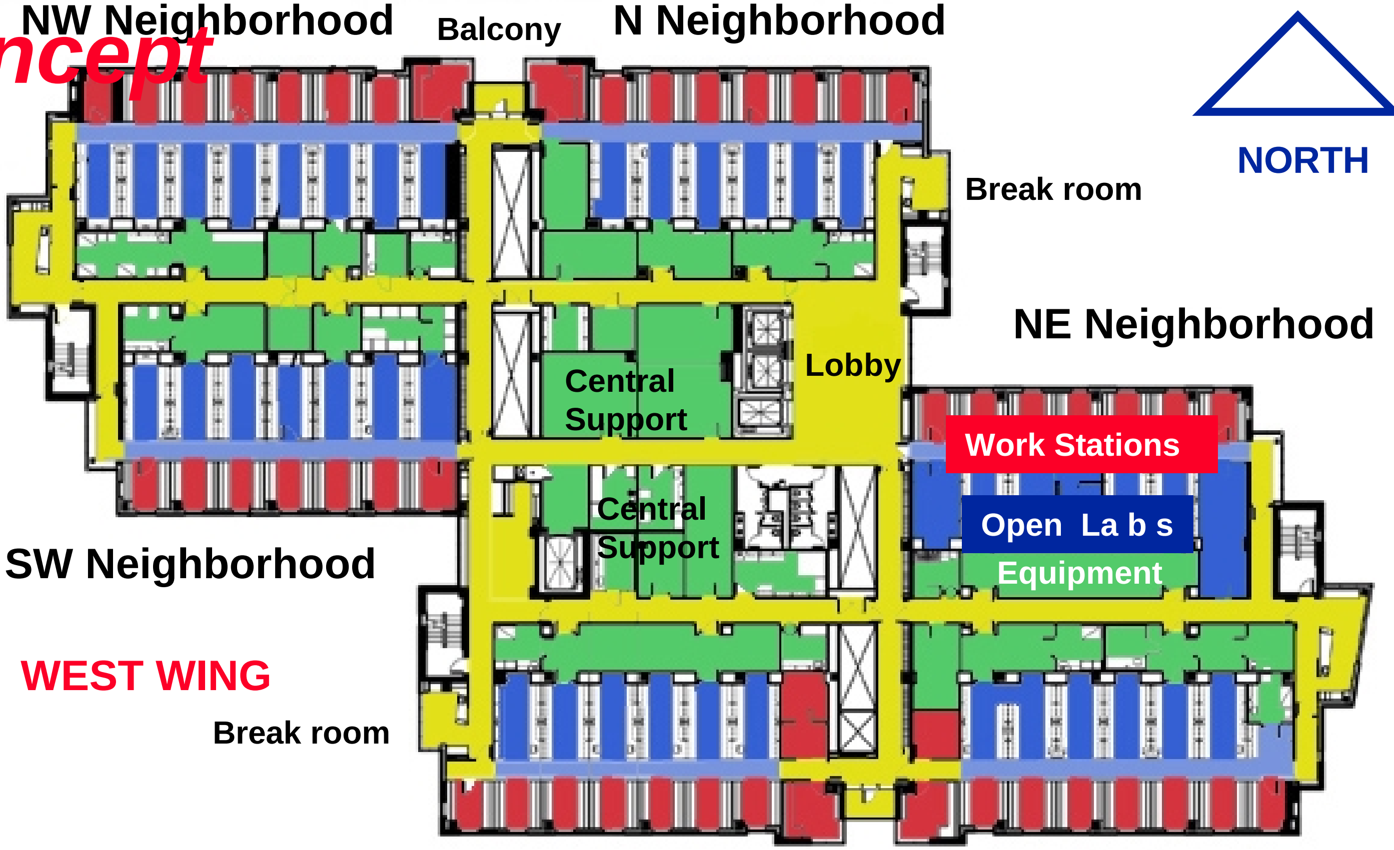
Typical Floor Plan - Neighborhood concept



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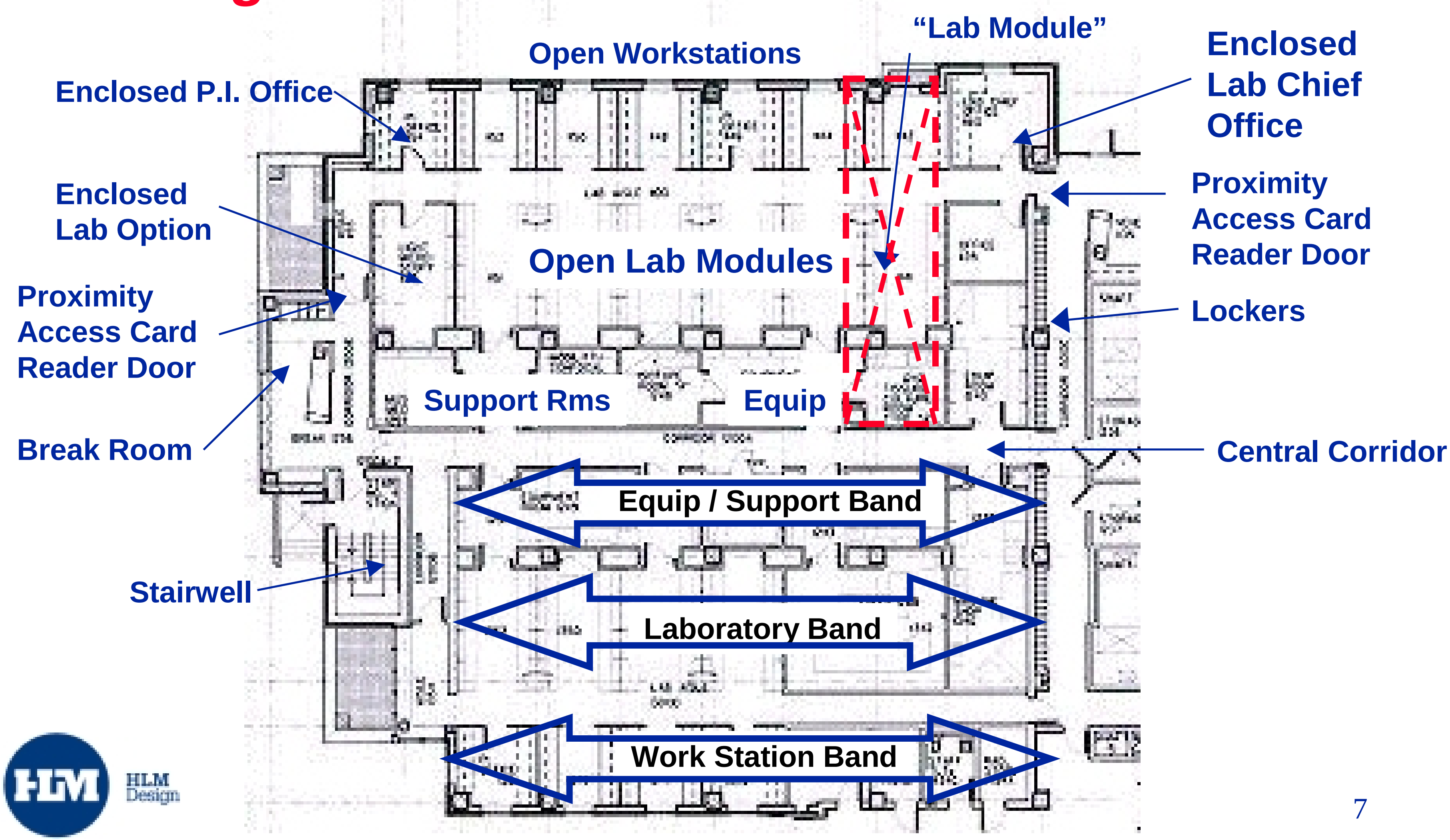
Lab Neighborhood Plan Detail



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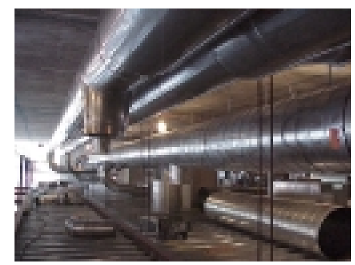
Modified Interstitial Concept

Exhaust Supply Walkway Supply Exhaust High Ceiling

Work stations Aisle Laboratory Equip / Support Corr Equip / Support Laboratory Aisle Work stations

Section through typical laboratory wing

- Cost effective lightweight steel deck
- Contains most HVAC, electrical, LAN and plumbing as well as Telephone LAN closets
- Running Supply and Exhaust down both sides avoids large duct crossovers and allows less interstitial height (7 feet clear)
- Efficient Improved Constructability
- Effective Future NIH Maintenance



Photos of Interstitial Level

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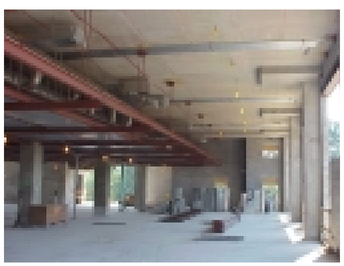
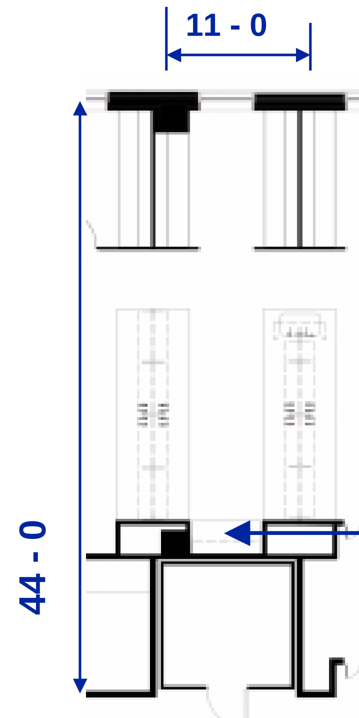
Lab Module Plan and Section - Daylighting

Section thru Lab and Workstations



Lab Neighborhood

Lab Window



Lab Module Plan

HLM Design

The mechanical interstitial ends at the line between the laboratory and the open lab aisle which creates a higher ceiling over the aisle and the workstations. This allows the use of double height windows to admit more daylight into the labs

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Mechanical Concerns in the Design of Energy Efficient Research Labs

- **The single largest energy consumer in Laboratories is the large amount of ventilation air required to maintain a safe environment, thus HVAC design concerns focus on this requirement.**
- **Building Supply and Exhaust Systems**
  - **Constant Volume or Variable Air Volume System**
- **Containment Devices (primarily fume hoods)**
  - **Constant Volume or Variable Air Volume Fume Hoods**
- **Use and Extent of Variable Frequency Drives**
- **Controls and Building Automation System**
- **Energy Recovery Systems**
  - **Decisions about extent and types of energy recovery**
  - **Initial Costs vs Life Cycle Costs**

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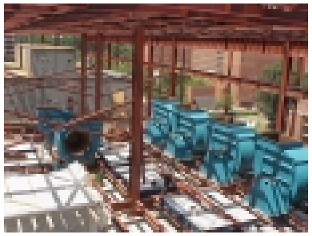
Mechanical System Basis of Design

- The design is based on an interstitial mechanical level concept
- Design Loads are 14 W / Sq Ft Building wide
- Major utilities are supplied from an adjacent utility tunnel; chilled water supply and return and high pressure steam & condensate return as well as city water and compressed air
- A basement mechanical room serves as the utility point of entrance and contains pumps, wet service and heat exchanger equipment.
- Piping distribution originates at the basement mech room and extends upward through the building in two major shafts
- A mechanical penthouse contains the main AHU's and exhaust fans
- The Supply and Exhaust system is Variable Air Volume with VFD fans
- 100% once thru air is tempered in eight 50,000 CFM VFD AHU's equipped with Energy Recovery wheels. The animal vivarium has a dedicated 50,000 CFM AHU
- Fume Hoods are VAV and do not exhaust through the Energy Wheels



Mech Penthouse

RMF ENGINEERING, INC. PROFESSIONAL ENGINEERS

Utility Tunnel

Basement Mech room

Utility Shafts

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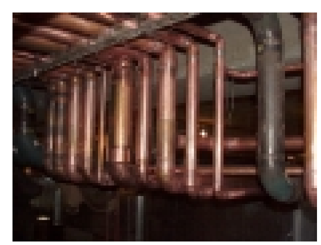
Mechanical System Basis of Design (Cont)

- There are separate exhaust systems for: general lab, fume hood, bathrooms, BL3 labs, vivarium, fermentation lab, cagewash and vivarium BL3.
- Exhausts exit the building 10 feet above the roof at 3000 FPM discharge
- Controls are Direct Digital Controls (DDC) with a Building Automation System
- The Energy Recovery Wheel provides pre heat, there is also a pre heat coil, but the primary heat is provided by terminal reheat coils in the terminal boxes. There also is perimeter hydronic room controlled baseboard heating at exterior glass areas.
- Lab piped utilities include vacuum, air, natural gas, CO2,lab industrial water, lab waste, secondary chilled water, reverse osmosis (R.O.) water, and Nitrogen.
- A clean steam system services the autoclaves and humidifies the building.
- Liquid Nitrogen is provided to specific limited locations in the NMR, freezer room and EM suites in the basement.
- An exterior tank farm is provided at the loading dock to supply bulk storage of Liquid Nitrogen, CO2 and nitrogen.
- The building is fully fire sprinklered, including the interstitial levels.

VAV Exhaust Fans

VAV Terminal Box

Energy Wheel



Lab Piping

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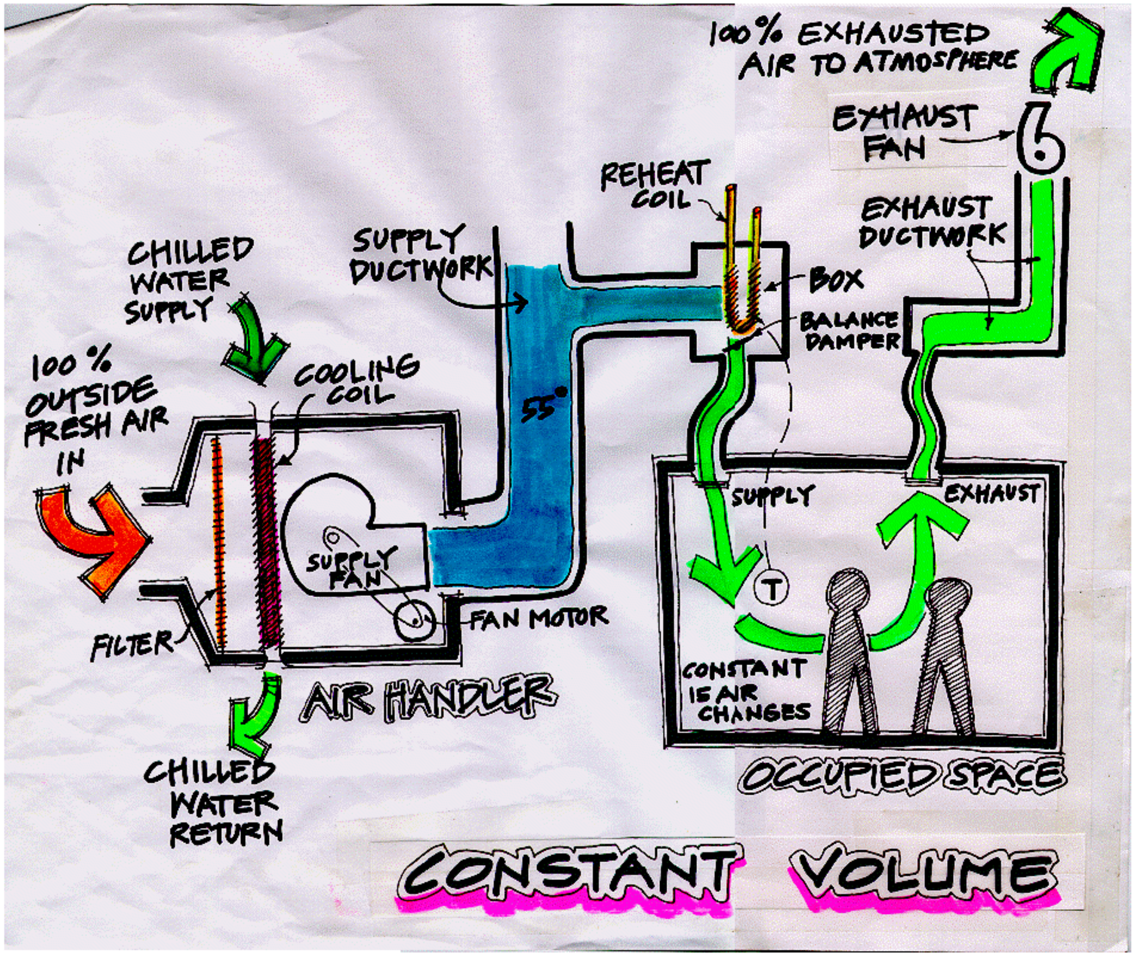
Constant Volume (CV) Systems

- Airflow / volume is constant
- Vary the temperature to meet demand
- Simple reliable and safe
- Easy to design, install, balance and maintain
- Very energy intensive
- Designers cannot apply diversity
- Systems not flexible to changes



Drawing by Frank Kutlak

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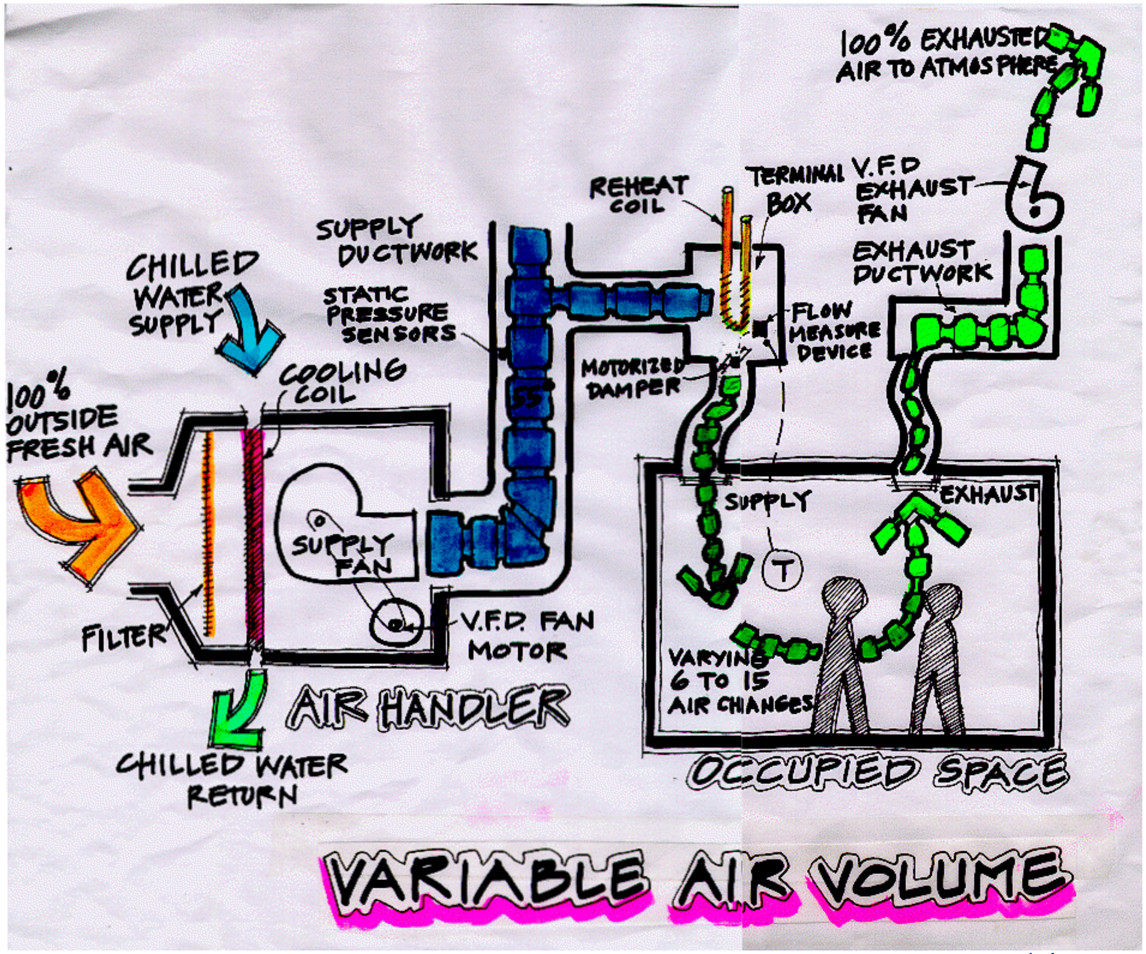
Variable Air Volume (VAV) Systems

- Airflow / volume and temperature is varied to demand
- Much more complicated and expensive controls
- Consumes 30% to 50% less energy than constant volume
- Designers can apply diversity
- System is very flexible to change



Drawing by Frank Kutlak

Considerations in Comparing CV and VAV Systems

- Design Guidelines of Users
- Load Profiles
- Climate - range of temperature and humidity deltas
- Initial Cost vs. Life Cycle Cost
- Energy Cost
- Maintenance staff capabilities
- Need for Flexibility

VAV Terminal Box

VAV Exhaust Fans

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Building 50 selected a VAV Supply and Exhaust System because:

- **The NIH Design Guidelines require once through air and allowed VAV and a turn down ratio of a minimum of 6 to a maximum of 15 Air Changes per hour.**
- **Load Profiles - there are varying loads in the building**
- **Climate - the range of temperature and humidity levels in Bethesda is moderate to high**
- **Cost - A Life Cycle Cost Study concluded short payback periods**
- **Energy Costs in the Mid Atlantic area are moderate**
- **NIH Maintenance staff has the capabilities for VAV**
- **Need for Flexibility - Change is frequent at NIH**

VAV Terminal Box

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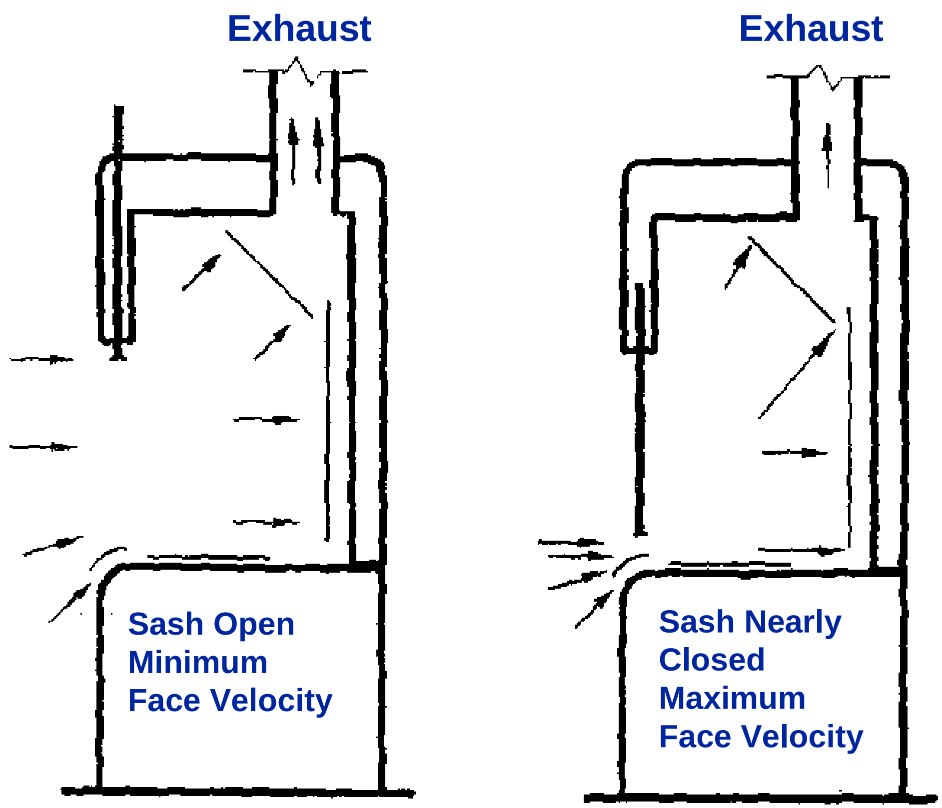
Fume Hoods

- Enclosed ventilated exhausted chamber
- Negative Pressure to contain and exhaust fumes
- Usually Sliding Sash for access
- "Face Velocity"
  - Volume and Speed of negative pressure airflow
  - Typically 100 Feet per Minute (FPM) + - 20%
  - This can equal 300 CFM in a 4 foot hood
- In a facility with a high density of hoods the hood demand can be the major building system design load
- 4 basic types of fume hoods
  - Conventional hoods
  - By-pass hoods
  - Auxiliary air hoods
  - Variable volume hoods

Conventional Fume Hoods

- Oldest, Cheapest and Simplest type of Fume Hood
- Basically an enclosed chamber with exhaust and sliding sash
- Face velocity is simply a function of the sash opening
- No way to provide uniform face velocity
- Creates low velocity at open sash position and high velocity when sash is nearly closed
- Can result in ineffective capture



Conventional Fume Hood Airflow Characteristics

From "Laboratory Control and Safety Solutions Application Guide" Landis & Gyr Inc. Rev 2- Sept 1994

Siemens Building Technologies, Inc.
Landis Division

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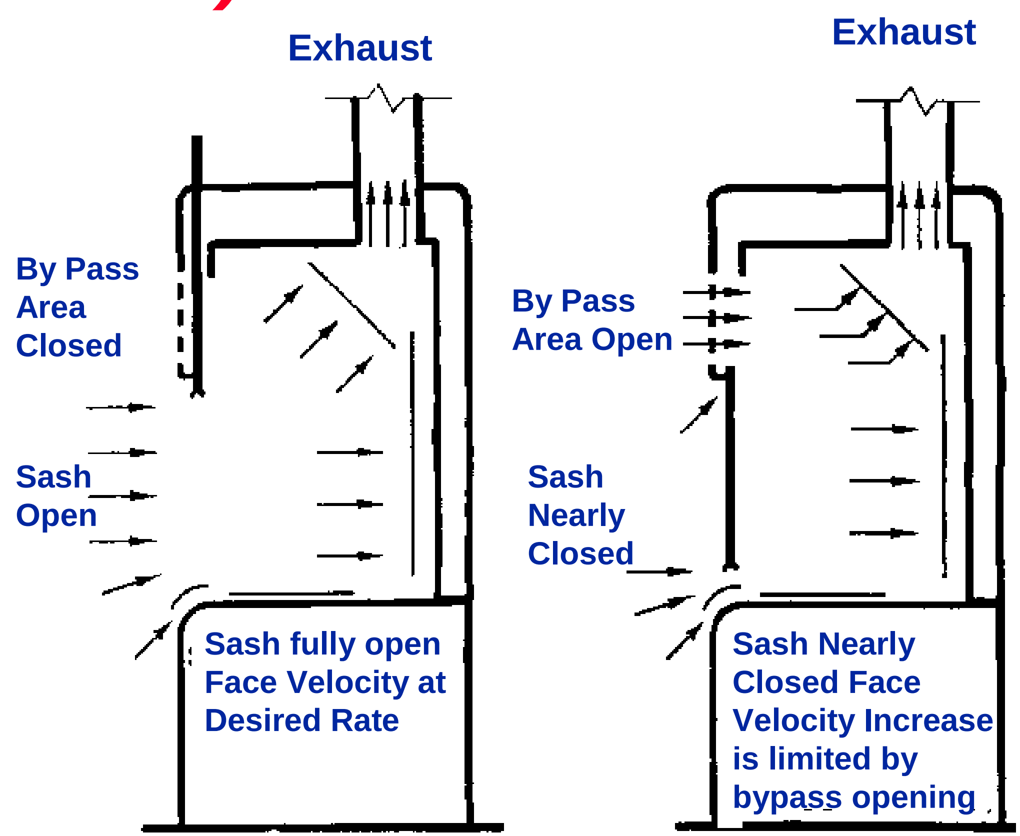
By-Pass (Constant Volume) Fume Hoods

- Air By Pass opening grille provided above sash
  - Opens and closes with sash to provide equivalent sash opening area
  - Maintains uniform face velocity regardless of sash position
- Simple but highest energy demand since constant volume is continuously exhausted
- Room must be rebalanced if hoods change



By Pass Fume Hood Airflow Characteristics

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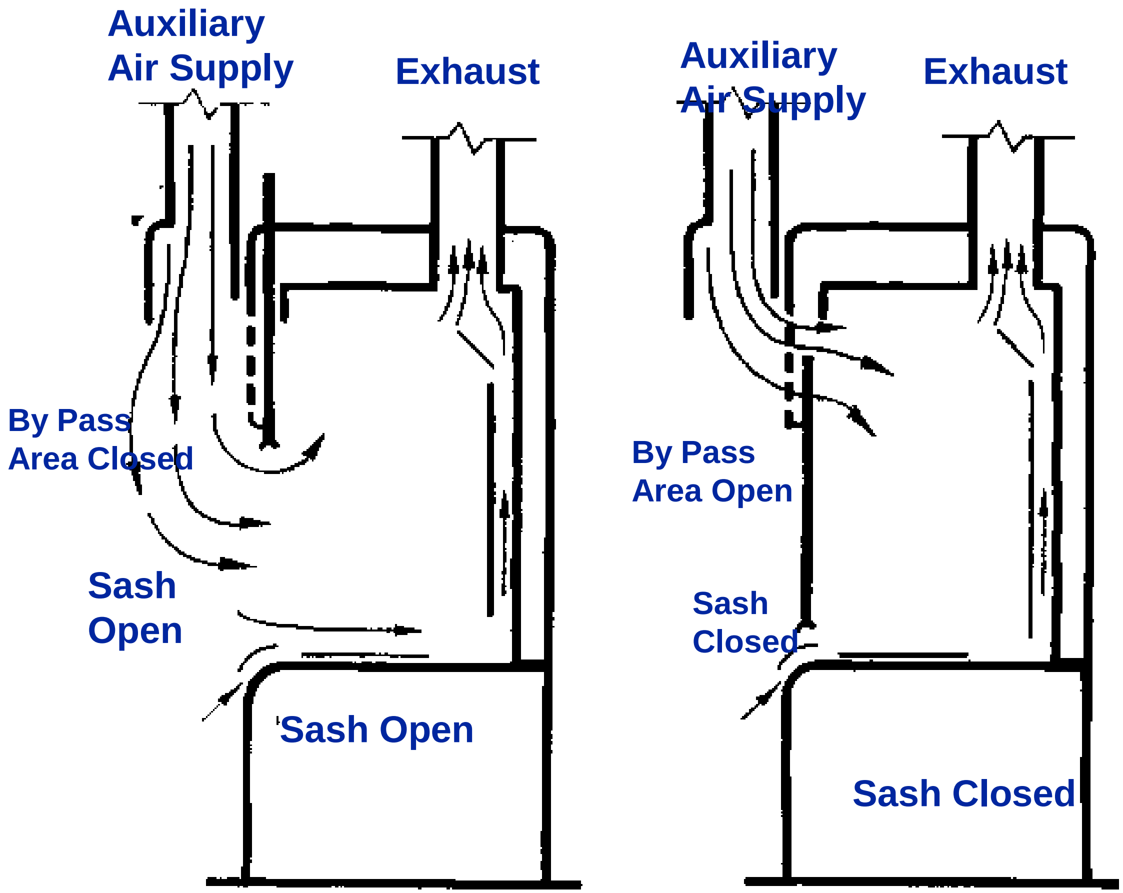
Auxiliary Air Fume Hoods

- Provides an auxiliary air supply to substitute for up to 70% of room air exhausted
- Known as “make -up air hood”
- Several Disadvantages
  - installation of auxiliary system can be costly & difficult
  - does not draw vapors out of room
  - introduces outside air temperature and humidity into hood



Auxiliary Air Fume Hood Airflow Characteristics

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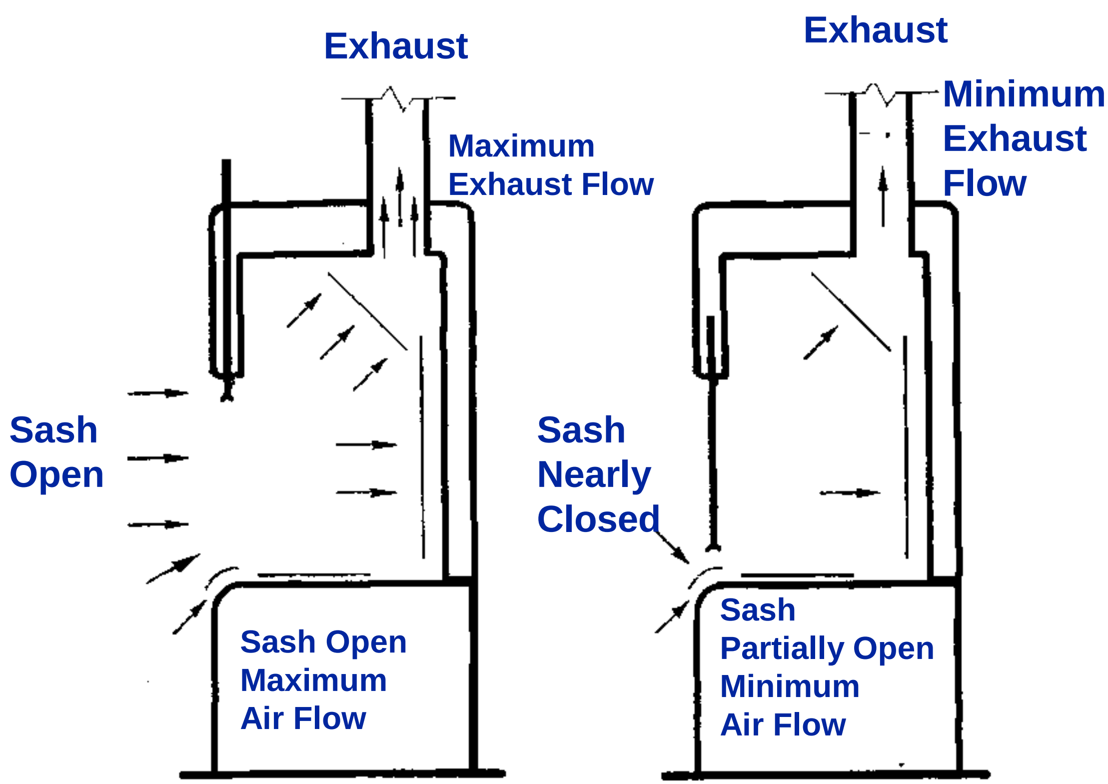
Variable Air Volume (VAV) hoods

- **Varies Exhaust Volume to maintain Face Velocity as Sash is opened or closed**
- **Only exhausts as much air as necessary to meet need**
- **Requires Sash monitoring system and fume hood controller tied into room supply and exhaust system**
- **VAV Hoods can be changed without rebalancing room**
- **Very complicated, much more difficult to design, install and commission**
- **More expensive initially but saves significant energy**



Variable Air Volume Fume Hood Airflow Characteristics

From "Laboratory Control and Safety Solutions Application Guide" Landis & Gyr Inc. Rev 2- Sept 1994

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Fume Hood Comparisons

- **Conventional Hoods**
  - simplest and cheapest but do not provide a uniform face velocity
- **Auxiliary Air, Make Up Hoods**
  - installation of auxiliary system can be difficult and costly
  - problems with introducing outside temperatures and humidity into the hoods
  - are not cost effective in harsh climates because outside air must be tempered
- **By Pass Constant Volume Hoods**
  - simple, safe and cheaper to install
  - have the highest energy demand since the constant volume is continuously exhausted
  - the hoods are a fixed condition and if changed the entire room must be rebalanced.
  - design cannot apply diversity - all hoods must run 100% continuously
  - can have "set back modes" but there are management problems associated with this in research labs which can be occupied at all times
- **Variable Volume Hoods**
  - more expensive and complex to design, install and commission
  - have the highest degree of face velocity control
  - independent hoods provide most lab flexibility - room does not have to be rebalanced
  - design can apply diversity (assume all hoods not used at once)
  - energy savings can be as high as 70% when compared to constant volume hoods

Fume Hood Comparisons - (continued)

- **Conventional Hoods and Auxiliary Air Hoods are not frequently used**
- **Comparison is usually between CV and VAV Fume Hoods and is similar to overall CV and VAV Central Supply & Exhaust Systems comparisons**
  - **Initial cost vs. life cycle cost**
    - **VAV more expensive but can save 30% to 70% of CV energy costs**
  - **Maintenance staff capabilities**
    - **VAV requires more highly trained maintenance**
  - **Need for flexibility**
    - **VAV is more flexible and responsive to change**
- **To realize VAV systems savings the users must be trained and cooperate in keeping the sashes closed except when the hoods are being loaded.**

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Building 50 Selected VAV Fume Hoods

- The NIH Design Guidelines allowed us to use a VAV Supply and Exhaust system and VAV hoods are most effective with this.
- VAV Hoods reduce the amount of air for hood exhaust and thus reduce the required airflow and energy costs of the air handling systems
- The initial costs are higher but the life cycle costs quickly payback the initial investment
- VAV Hoods are independent and changes can be made without having to rebalance the entire system, which is an advantage at NIH where change is constant.
- Building 50 is the first facility at NIH to install VAV Hoods, all previous fume hoods campus wide are Constant Volume By Pass hoods
- This will make it necessary to stress to the occupants that hoods must be closed except when they are being loaded, for maximum energy efficiency

Variable Frequency Drives - VFD's

- In the past motors were either "on" or "off"; there were some two speed motors but basically they ran at fixed RPM's. Inlet vanes were used but were maintenance intensive.
- A variable frequency controller is a solid state device that varies the output frequency of standard 50 or 60 cycle input power to provide varying motor speeds
- Since power required to run motors of fans and pumps is proportionate to the cube of it's speed; large reductions in energy occur at lower speeds
- Developments in variable frequency motor speed controls have increased reliability and lowered costs to a point that VFD is preferred for most applications
- Negatives of VFD's are increased initial cost, noise and harmonic distortions of current flow
- By pass circuitry to allow the manual operation is helpful for maintenance or in the event of a VFD drive outage
- *Building 50 Uses VFD's on all major fans, motors and pumps*
- The VFD's on the Building 50 fan systems vary the speed of the VAV supply and exhaust fans as required by load demands from a minimum of 160,000 CFM (6 air changes per hour) to a maximum of 400,000 CFM (15 air changes per hour) .
- The VFD's on the pump system operate much the same way except the air terminal units are replaced by water control valves and cooling and heating coils.

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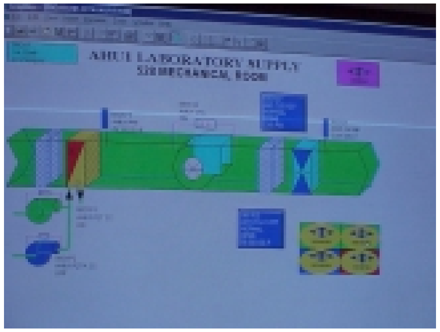
Building Controls

- DDC technology offers greater safety and energy efficiency
- Controls for the mechanical HVAC building systems are Direct Digital Control (DDC) with pneumatic actuators
- A Building Automation System (BAS) provides a central computer station in the maintenance office with 3000 distinct control points and
  - Graphic displays of AHU's, exhaust fans, fume hoods, VAV terminal units, room temperature, room differential pressure, pumps, heat exchangers, and central utility consumption
  - Alarms and maintenance reminders are displayed automatically
- This enables the engineering maintenance staff to control, trend and monitor all of the equipment throughout the building
- There is a second read only computer monitor in the animal facility office so the vets can monitor and keep records of the vivarium's conditions



BAS Screen Graphic

Energy Recovery Systems

- The single most important and largest application of energy recovery in research Facilities is the heat recovery in the laboratory exhaust systems
- This can be accomplished with:
- Plate Type- thin metallic sheets in air streams
- Heat Pipe - horizontal tubes with liquid refrigerant in air streams
  - positive separation, no moving parts, moderate cost, low maintenance
  - air streams must be side by side, systems are 50 % to 70% effective
  - sensible heat transfer only; no latent (moisture) energy recovery
- Run Around Coils - 2 air to liquid heat exchangers in air streams
  - positive separation, moderate cost, 45% to 65% effective,
  - sensible heat transfer only ; no latent (moisture) energy recovery
  - can be remote, air streams do not have to be side by side
  - liquids have to be pumped, requiring energy and more maintenance
- Heat Wheels - heat absorbing dessicant disk rotates sequentially through and transfers energy from the exhaust and supply airstreams
  - recovers sensible and latent energy, higher efficiency of 70%to 80%
  - air streams must be side by side, potential for contamination between them
  - higher initial cost, moving parts requiring more energy and maintenance

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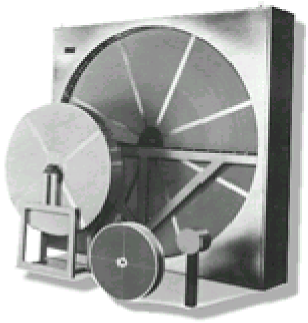
Energy Recovery Wheel Concept and HVAC System Design Issues



- Concerns about possible cross contamination
  - Cross Contamination has been limited to 0.04% in tests
- Confidence to downsize base design capacity to benefit from Energy Recovery savings
  - Maximum savings are achieved if base building design is reduced to take full advantage of the energy recovery of the wheels ("rightsizing")
- Additional construction costs required to accommodate wheels
  - Supply and Exhaust Airstreams must be channeled adjacent to each other to allow wheel to alternately rotate through both
  - Mechanical Penthouse must have additional height for taller AHU
- Pay back periods
  - A life cycle study must be made to compare initial costs and life cycle energy savings
    - In most cases of once through air, dessicant energy recovery wheels provide almost immediate or short pay back periods

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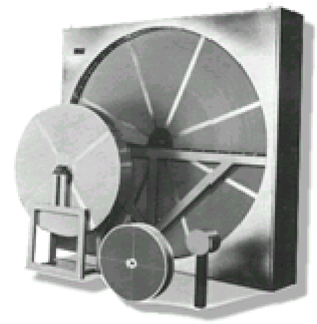
Building 50 Selected a Dessicant Energy Recovery Wheel Concept



- **A complete Life Cycle Cost study was conducted on all of the various types of energy recovery systems. The dessicant energy recovery wheel concept was by far the most cost effective system.**
- **A major factor is that this is the only system that recovers latent as well as sensible energy, which is very important in the high humidity summer conditions in Bethesda.**
- **Based on prior successful applications on similar laboratory facilities at nearby Johns Hopkins and Georgetown Universities, RMF, the mechanical engineering consultant highly recommended this dessicant energy recovery wheel concept.**
- **NIH researched these two projects and found them to be highly successful**
  - **The Office of Research Services, Division of Safety and Division of Engineering, Maintenance Engineering Section personnel visited both sites and carefully considered all of the advantages and disadvantages of the energy recovery wheel concept.**

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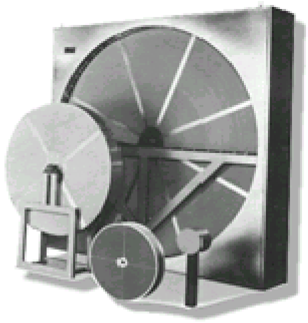
NIH accepted the Energy Recovery Wheel Concept with the following limitations:

- The Office of Research Services carefully considered the dessicant energy recovery wheel concept in the design of Building 50 and accepted it with the following conditions/ restrictions:



  - Division of Safety
    - No containment devices exhausted through the wheels
    - They do not want to risk re-entrainment of contaminants
    - This requires a separate fume hood exhaust system and results in less volume of air to the wheels, and thus less energy savings
  - Division of Engineering / Maintenance Engineering Branch
    - Design / Size base building system without heat wheel factors
    - They are concerned about insufficient building capacity if for any reason the energy wheels had to be abandoned in the future
    - This results in us not realizing the maximum benefit of downsizing the building base system design to take full advantage of the energy recovery of the wheels

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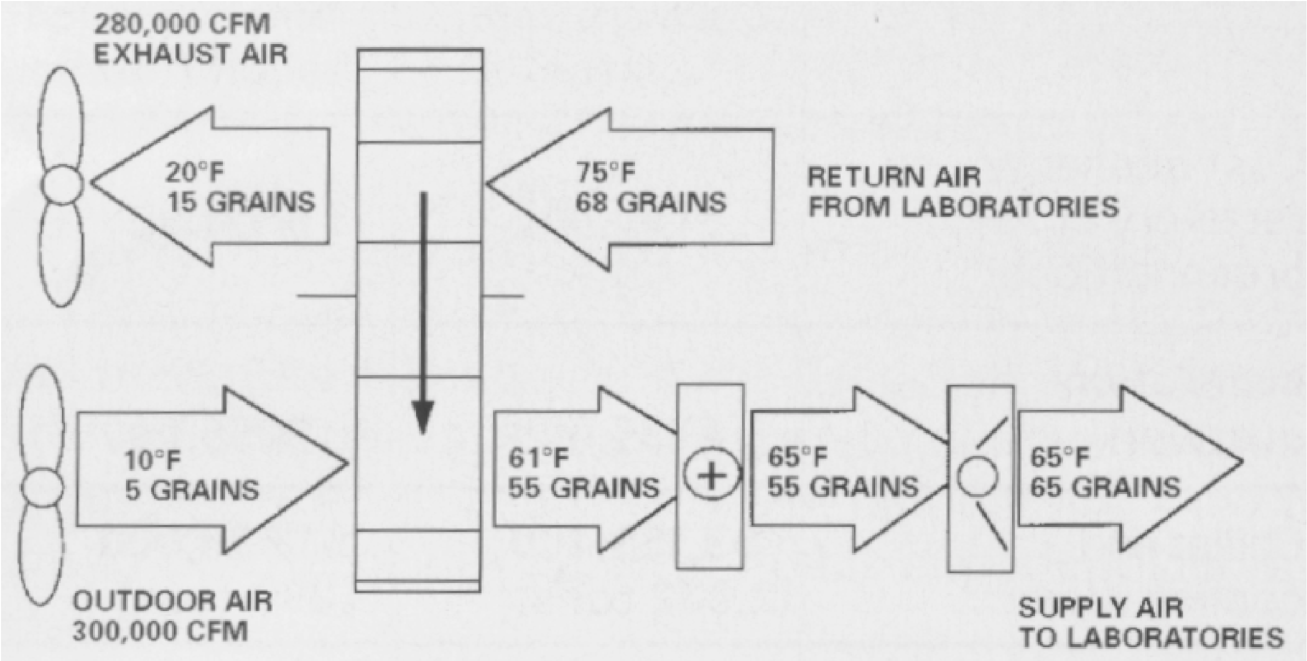
Energy Recovery Wheel Concept - Heating

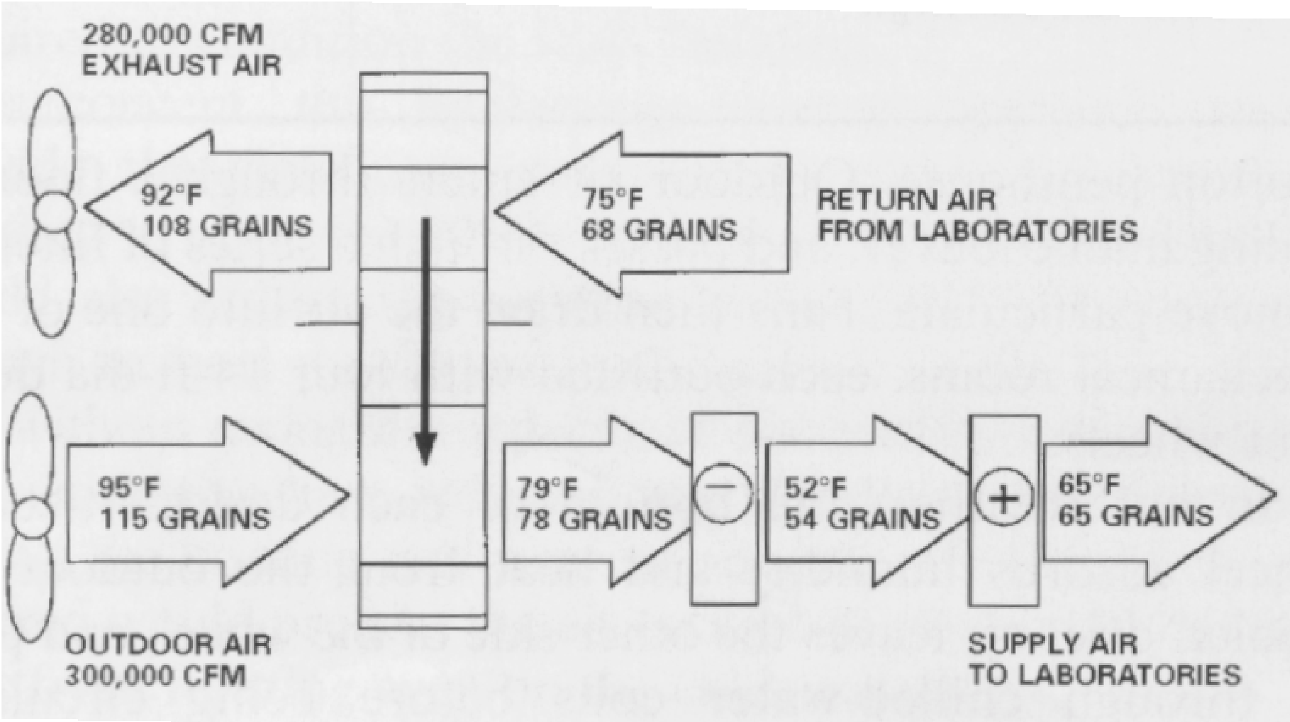
- **Outgoing Warmer Air Exhaust Flow raises the temperature of the energy wheel**
- **which in turn then spins through and raises the temperature of the cooler incoming outdoor air**



Schematic of Energy Recovery Wheel in Heating Mode

Energy Recovery Wheel Concept - Cooling

- **Outgoing Cool Air Exhaust Flow lowers the temperature of the Energy Recovery wheel**
- **which in turn then spins through and lowers the temperature of the incoming outdoor air**



Schematic of Energy Recovery Wheel in Cooling Mode

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Energy Recovery Wheel Concept
Humidity in Heating Mode

In the heating season the water vapor in the humid exhaust air is absorbed by the energy wheel and retained. It is then captured by and humidifies the incoming drier supply air.

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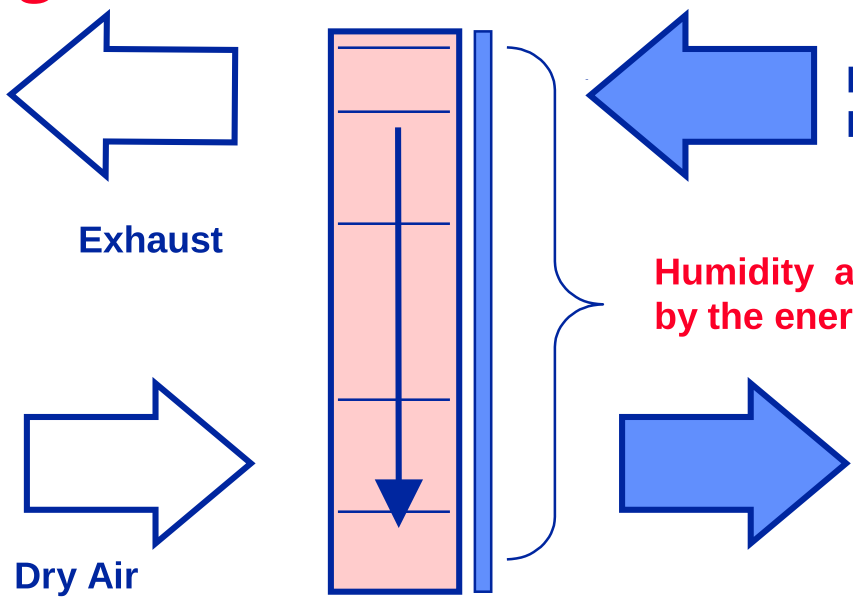

Schematic of Humidity Retention in Heating Mode

Drawing by Frank Kutlak

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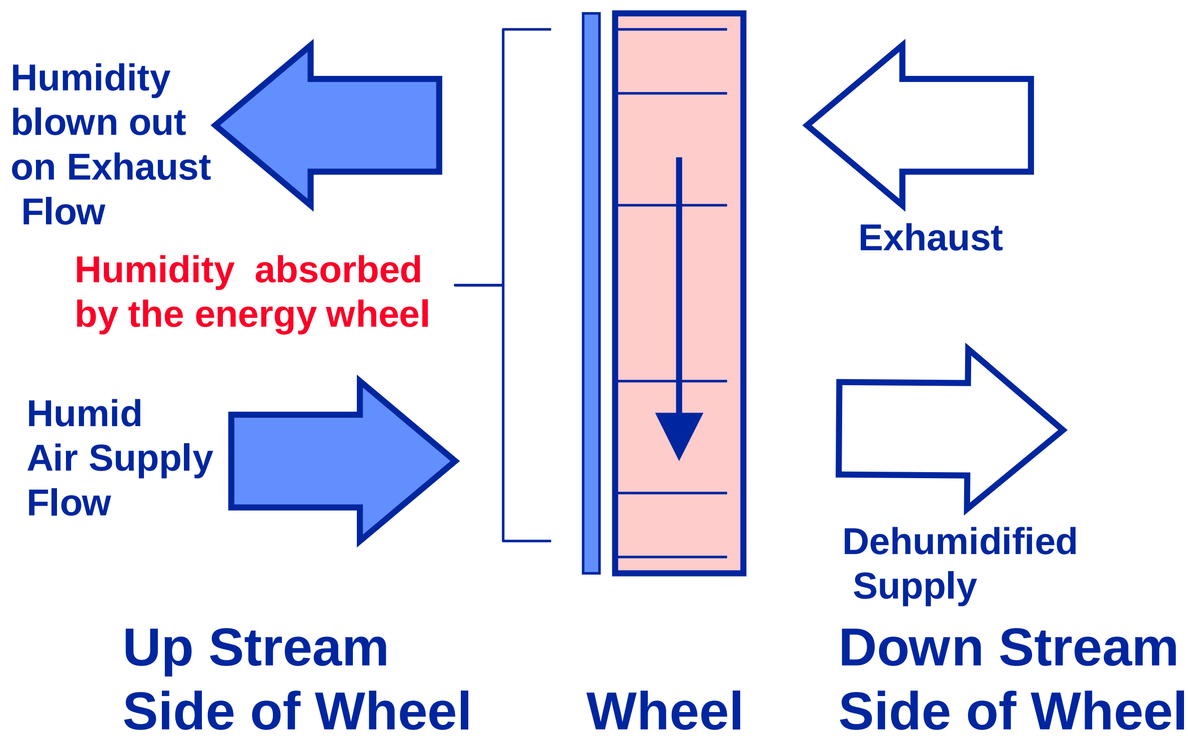
Energy Recovery Wheel Concept
Humidity on Cooling Mode

In the cooling season the water vapor in the humid supply air is absorbed by the energy wheel and filtered out of the supply. It is then rejected by the exhaust flow.



Schematic of Humidity Rejection in Cooling Mode

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Drawing by Frank Kutlak

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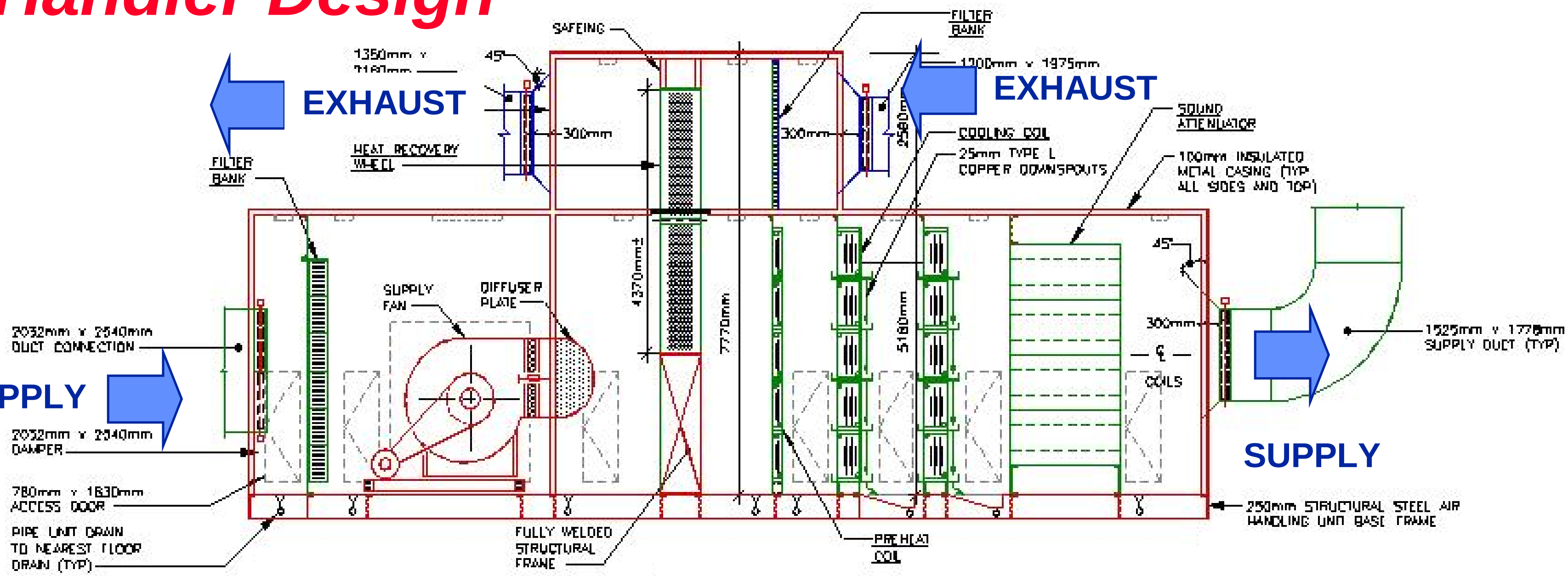
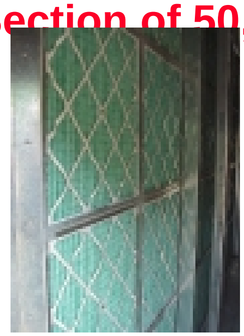
NIH BUILDING 50

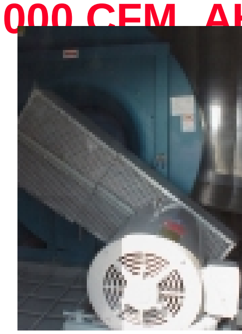
Air Handler Design



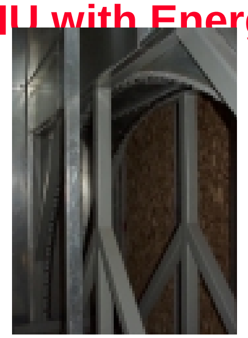
- **Section of 50,000 CFM AHU with Energy Recovery Wheel**



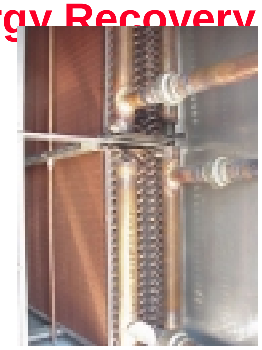
Filter Bank



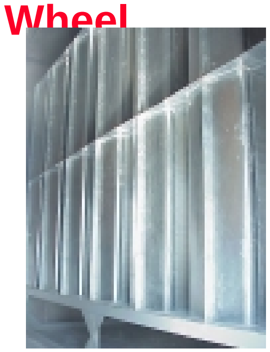
Fan Motor and Fan



Heat Wheel



Cooling Coil



Sound Attenuator

AHU being installed

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Energy Recovery Wheel

- Section of the Building 50 Custom Air Handler with SEMCO Energy Recovery Wheel frame installed in the fabrication yard of Energy Labs Inc. in Tijuana Mexico
- Each AHU will be shipped in 5 bottom and 1 top sections.
- The actual Energy Recovery Wheel will be installed in the field

Energy Labs Inc

SEMCO INCORPORATED

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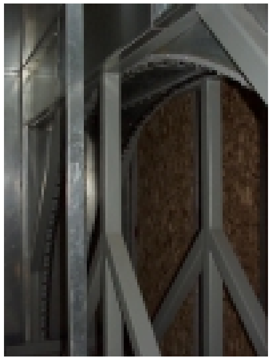
NIH BUILDING 50

NIH Building 50 Energy Conservation Features

- ## Mechanical Systems

There are five major mechanical elements that contribute to the increased energy efficiency of Building 50.



Heat Wheel

- **Energy Recovery Wheels**
- **Variable Air Volume (VAV) Supply and Exhaust Systems**
- **Variable Frequency Drive (VFD) fans**
- **Variable Frequency Drive (VFD) pumps**
- **Variable Air Volume (VAV) fume hoods**

VAV Exhaust Fans

VAV Terminal Boxes

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Electrical Concerns in the Design of Energy Efficient Research Labs

- **Power Design Levels and System configuration**
  - **Establish connected load power requirement building wide**
  - **Use diversity factor for estimated real power consumption load**
  - **Provide adequate, reliable, uniform and cost effective power**
- **Lighting -**
  - **Establish Light Levels, Fixture Types and Controls**
  - **Stress efficient fixtures and controls**
- **Emergency Power and /or Uninterruptable Power Supply (UPS)**
  - **Clearly differentiate between Emergency and Uninterruptable Power, determine true needs, extent and location of service.**
- **Provide room for future growth in all electrical services**
  - **Provide determined percentage of unused breakers and blank knock-outs in all normal and emergency power panels**

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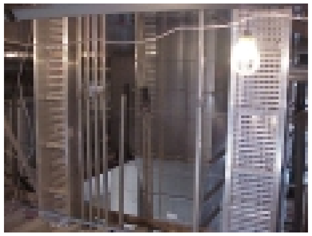
NIH BUILDING 50

Electrical System Basis of Design

- **3 - 13.8 KV 3 conductor 500 MCM PILC primary feeders supply power**
- **3 Transformer Network System, 2500 KVA each, 1 redundant**
- **Building gross design load was 20 VA /Sq Ft for a total of 5000 KVA**
- **Network Protectors are 4500 AMPS 480 / 277**
- **Secondary Switchgear 4000 AMPS 480 /277**
- **Vertical Distribution is 2 vertical 1600 Amp cable bus in shafts**
- **Floor Distribution is 2 each,112.5 and 225 KVA dry transformers with 208/120 distribution panels, 225 amp branch circuits; with 42 circuits per each 2 lab modules panel**
- **Each lab bench is fed by 1 60 amp circuit with single pole 20 amp circuit breakers in a wiremold raceway**

Main Transformer

Switchgear



Cable Bus

Transformer in Interstitial

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Electrical System Basis of Design (Cont)

- **Emergency Power system is sized at 6.8 W /Sq Ft or 1800 KW provided by an exterior modular skid mounted 1500 Horsepower weatherproof soundproof diesel generator, with a fuel tank to provide 48 hour run time**
- **A 1600 KW air cooled load bank will be provided**
- **4 automatic transfer switches are provided to serve life safety, lab emergency equipment, emergency mechanical equipment and the fire pump**
- **Lighting is primarily T-8 fluorescent lamps with electronic ballasts**
- **A programmable lighting control is provided, as are motion detectors**
- **A Local area Network LAN is provided throughout the building on cable tray in the interstitial level. Telephone and Lan rooms are located on each interstitial level.**

A proximity card reader system will provide access control throughout the building.Each neighborhood will have a secured perimeter

Cable tray

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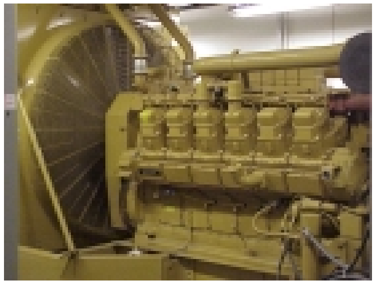
NIH BUILDING 50

NIH Building 50 Energy Conservation Features

Electrical Systems

- Power - gross design load was 20 VA /Sq Ft for a total of 5000 KVA
- Lighting
  - High efficiency T-8 lamps with electronic ballasts
  - LED exit signs
  - Architecture provides large windows for daylighting; Electrical provides photocells to control main lighting
  - Use of task lighting at personal work stations;
  - Programmable lighting control system turns all lights off at night
  - Motion detectors in enclosed rooms to turn lights off when unoccupied

- Emergency power provided at 6.8 W /Sq Ft or 1800 KW
- UPS power optional provided by user locally or installed in interstitial at extra cost to user



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Utility Consumption Rates

- **Metering - All Utilities are metered so the building's energy usage can be tracked and benchmarked - a first at NIH**

- **With energy recovery wheels :**
  - **chilled water: 2150 tons**
  - **steam: 48,250 lb/hr**
- **Without energy recovery wheels :**
  - **chilled water 3605 tons**
  - **steam: 85,000 lb/hr**

Note that the energy recovery wheels result in estimated savings of 40% in chilled water and steam

(steam is used for process equipment such as autoclaves, as well as heating, & humidification)

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NIH BUILDING 50

Utility Consumption Rates & Rebate

- Electrical Power - Design Load was 17 W / Sq Ft (5000 KVA)
- Power Consumption is estimated at 10 to 12 W / Sq Ft (or 3000 to 3500 KVA)
- Emergency Generator is designed at 6.8 W / Sq Ft - 1800 KW
- Natural Gas - 940 Cubic Feet / Hour
- Water - 540 gallons / Minute
- **Building 50 Rebate** - due in a large part to the Energy Recovery Wheels, the local energy provider, PEPCO, will be issuing a rebate calculated at $2 million because of the energy savings that will result from the various energy efficient devices in the design of the facility.

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NIH BUILDING 50

Fume Hood Mock Up and Testing

- Goal of testing was to Prequalify the VAV Lab Fume Hood and Fume Hood Control System
  - Verify hoods can meet specified containment criteria
  - Verify control system can meet specified performance criteria
  - Assess quality of overall Lab / Fume Hood configuration
- BELL Created a Simulated Lab Module with all actual Building 50 components
- The testing involved the following entities

  The BELL Company, General Contractor
  ISEC, the hood supplier; SIEMENS, the Controls Contractor;
  RMF, the Mechanical Engineer; CRSS, the Construction Manager
  FACILITIES DYNAMICS, the Commissioning Agent;
  WEISMAN INC, the Testing and Balancing Contractor;
  ADELAIDE ASSOCIATES, conducted ASHRAE110 tests
  NIH / ORS Div of Safety and Div of Engineering

Louis Stokes Laboratory

Fume Hood Testing for Simulated Lab Module

Facility Dynamics

Fume Hood Testing Report

CRSS Constructors A Jacobs Company · rmf · Facility Dynamics Engineering · WEISMAN INC. · BELL · ISEC · Office of Research Services · Siemens

Laboratory case study

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Fume Hood Mock Up Configuration

2 Hoods on the VAV exhaust up stream

Fume Hood Alcove with test hood

- The BELL Company created a mock up in an EPA lab they were constructing
- 2 hoods were installed upstream to simulate adjacent lab fume hood use
- A plywood mock up wall created the Building 50 Alcove configuration with
  - VAV fume hoods
  - Supply and Exhaust VAV Terminal Boxes
  - 1 Exhaust Inlet and 1 Supply Outlet
  - Tracking System - Lab Room Controller, fume hood controller and hood exhaust control valve

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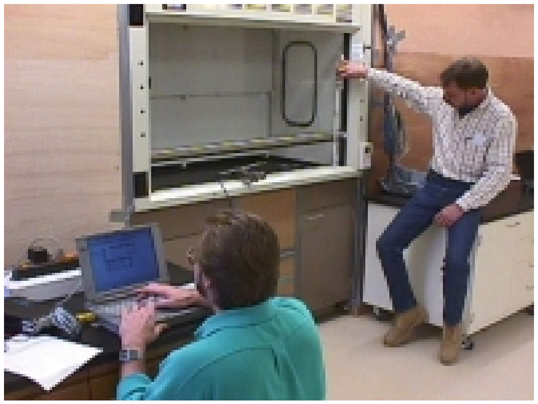
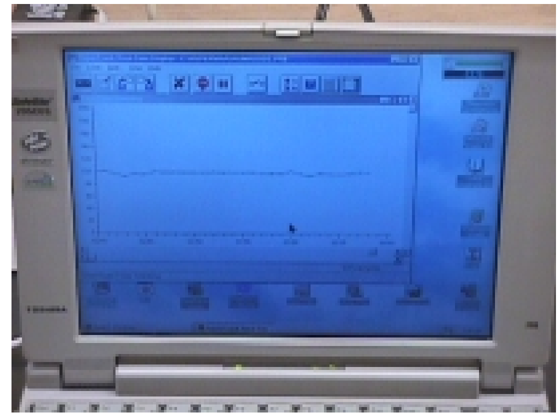
NIH BUILDING 50

Fume Hood Testing - Face Velocity and Dynamic Response Testing



Measuring Face Velocities at differing sash openings

Computerized recording and graphing of the dynamic events



- **Face Velocity Test - a grid of face velocity measurements was taken across the face of the hood with the sash in various positions**
- **Dynamic Response tests - response testing measures the hood performance in various "dynamic events" such as sash movements, walk bys and opening and closing the lab door or opening and closing upstream fume hoods; for:**
  - **steady state face velocity**
  - **maximum deviation**
  - **time to steady state**
  - **overshoot**

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NIH BUILDING 50

Fume Hood Testing - Tracer Gas Containment Tests

Containment test using Manikin with detector probe

ASHRAE 110 with NIH modifications to more truly simulate loaded fume hood condition

- **Tracer Gas Containment - this addresses the containment of the hood with a sulpher hexafluoride gas release and a detector on the face of a manikin.**
- **The well known <u>ASHRAE 110 -Method of Testing Performance of Laboratory Fume Hoods110</u> was modified slightly by NIH with the addition several elements to simulate actual apparatus in the Hood.**

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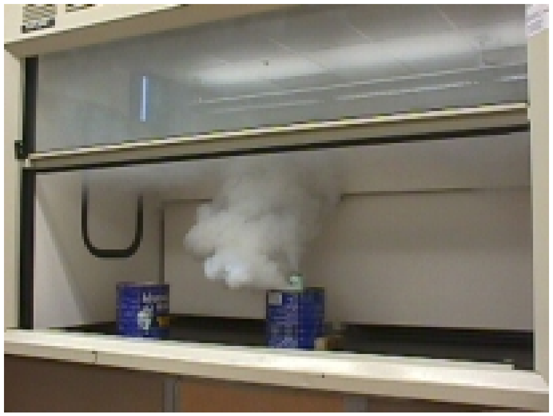
NIH BUILDING 50

Fume Hood Testing - Flow Visualization Testing



Large volume smoke bomb set off in hood

Sash is raised and lowered; smoke is contained in hood

- Large Volume visualization - a smoke bomb was set off to look for leakage in static & dynamic (sash movement and walk by) conditions.
- Local Visualization - using a titanium tetrachloride smoke gun to check for small leaks around the edges of the hood
- All large volume and local visualization tests indicated that the capture was adequate under all conditions including rapid sash movement.
- The overall results of the fume hood mock up and testing were that the configuration performed very well on most aspects of the test and that the proposed system can meet the intent of the requirements and provide a safe installation.

Laboratory case study

Air Handler Testing

- **The Bldg 50 Management team visited the Energy Labs factory to participate in the testing of the Custom Air Handlers**
- **The Tests included**
  - **Overall Conformance to Contract Documents and Quality Inspection**
  - **Fan Volume Testing**
  - **Leak Testing of Unit**
  - **Face Velocity Across Coils**

Energy Labs Inc

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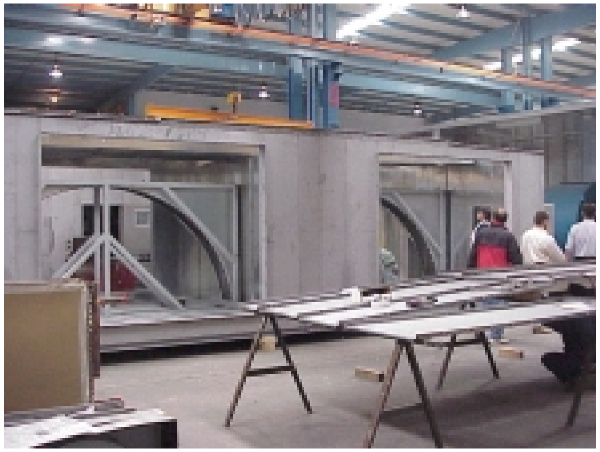

Building 50 AHU sections in factory production line

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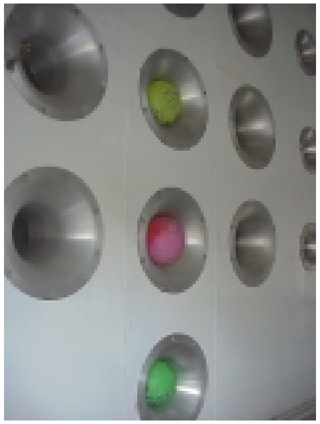
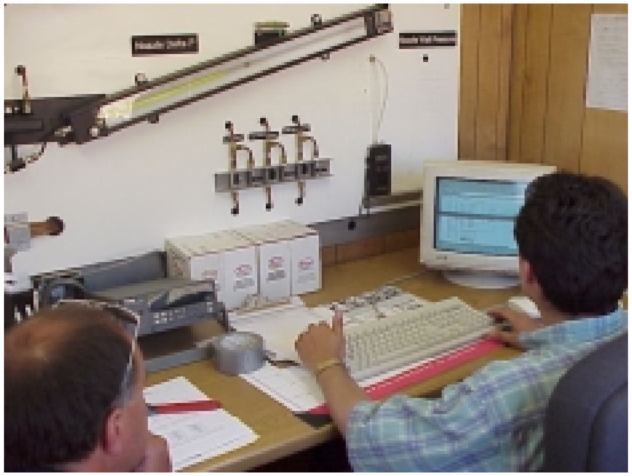
NIH BUILDING 50

Air Handler Testing

Building 50 AHU in background connected to test chamber in foreground



Interior of test chamber with funnels to measure fan output



Reviewing Instrument readouts in testing office.

Energy Labs Inc

RMF Engineering, Inc. Professional Engineers

- Energy Labs has a testing chamber they use to verify the AHU fan output

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NIH BUILDING 50

Air Handler Testing

Leak Testing. Entire Unit is pressurized to check for leaks.

Two RMF Mechanical Engineers take readings to verify uniform velocity across face of the coils

- **AHU's were tested for leaks and uniform velocity across the face of the coils**
- **Overall the units passed all of the tests and had minimal quality issues which were corrected**

Energy Labs Inc

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Air Handler Installation

BELL

- The units had to be transported from California on 30 escorted tractor trailers to a holding yard in Baltimore
- The 8 main roof top air handlers were comprised of 28 sections weighing from 12,000 to 38,000 lbs each
- BELL had to lease a 200 ton crane with a special jib boom to lift them to the mechanical penthouse

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NIH BUILDING 50

Air Handler Installation

Setting last section of AHU #2 in West wing

- **The AHU sections were carefully set on steel framing over an acoustical slab in the west and east wings.**

BELL

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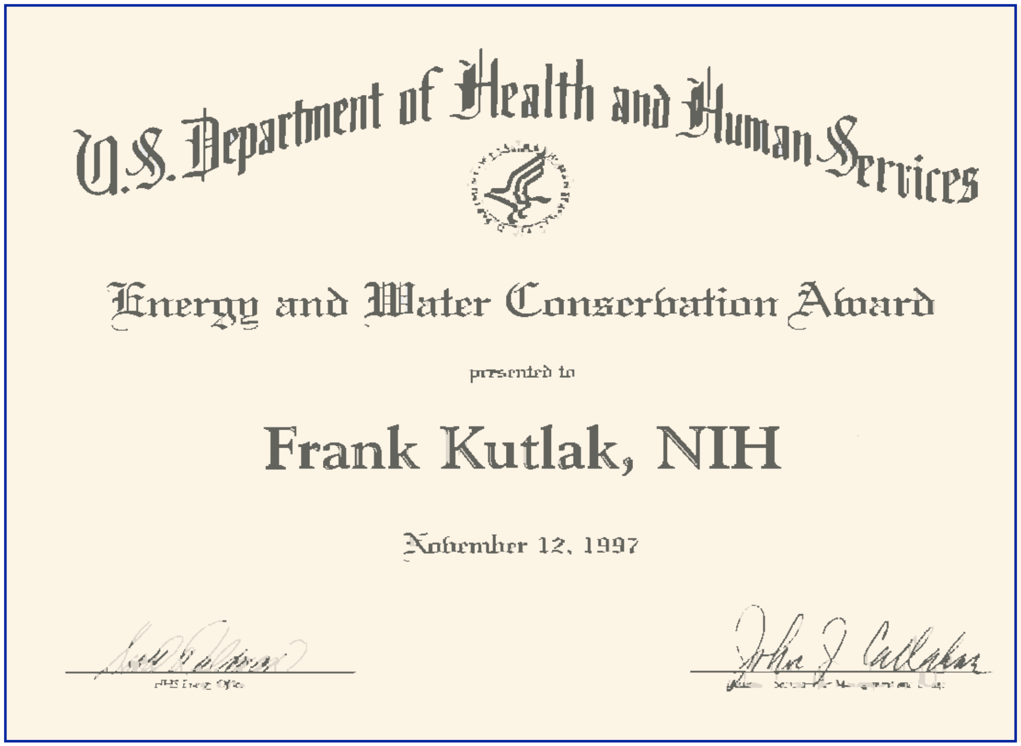
HHS Energy Award


U.S. Department of Health and Human Services

Energy and Water Conservation Award

presented to

Frank Kutlak, NIH

November 12, 1997

The Louis Stokes Laboratories / Building 50 was awarded the 1997 Dept of Health and Human Services National "Energy and Water Conservation Award' for it's efficient energy design

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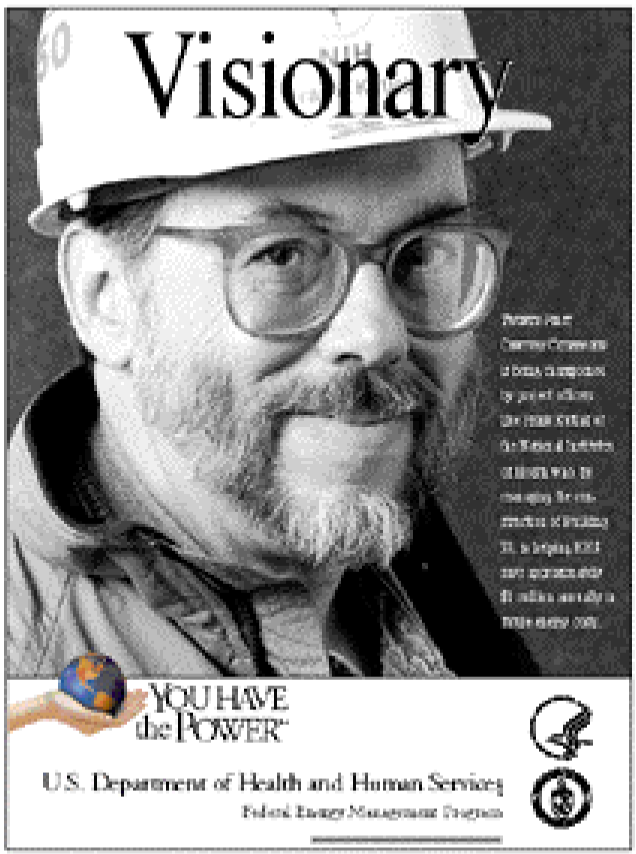
DOE / FEMP - Federal Energy Management Program
"You Have the Power" Campaign



1998 Energy Champion

Frank Kutlak - Architect / Project Officer
Department of Health and Human Services

Twenty- First Century Citizenship is being championed by Project Officers like Frank Kutlak of the Office of Research Services at the National Institutes of Health who, by managing the construction of Building 50, is helping HHS save approximately 40% in future energy costs.

Laboratory case study

Office of Research Services

NIH BUILDING 50

Project Credits

- Owner - National Institutes of Health
  Office of Research Services
  Division of Engineering Services
  Design, Construction & Alterations Branch

Building A Better NIH

Design, Construction and Alterations Branch | Division of Engineering Services | Office of Research Services

- Architect - HLM Design Inc, Bethesda MD
- Engineers - RMF Engineering, Baltimore MD
- Construction Manager- CRSS Constructors Arlington VA
- Commissioning Agent - Facility Dynamics, Columbia MD
- Testing and Balancing Consultant - Weisman Inc Towson MD

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NIH BUILDING 50

Project Credits (Cont)

- **General Contractor and Mechanical Contractor**
  The BELL Company, Kensington MD
- **HVAC Sub Contractor - Stromberg Metals, Beltsville MD**
- **Elect Sub Contractor. - Young Electric, Olney MD**
- **Air Handlers - Energy Labs, San Diego CA**
- **Energy Wheels - Semco**
- **Fume Hoods - ISEC, Fisher Hamilton**
- **Controls - Siemens**

BELL

YE

Energy
Labs
Inc

SEMCO INCORPORATED

ISEC

Fisher Hamilton

Siemens Building Technologies, Inc.
Landis Division

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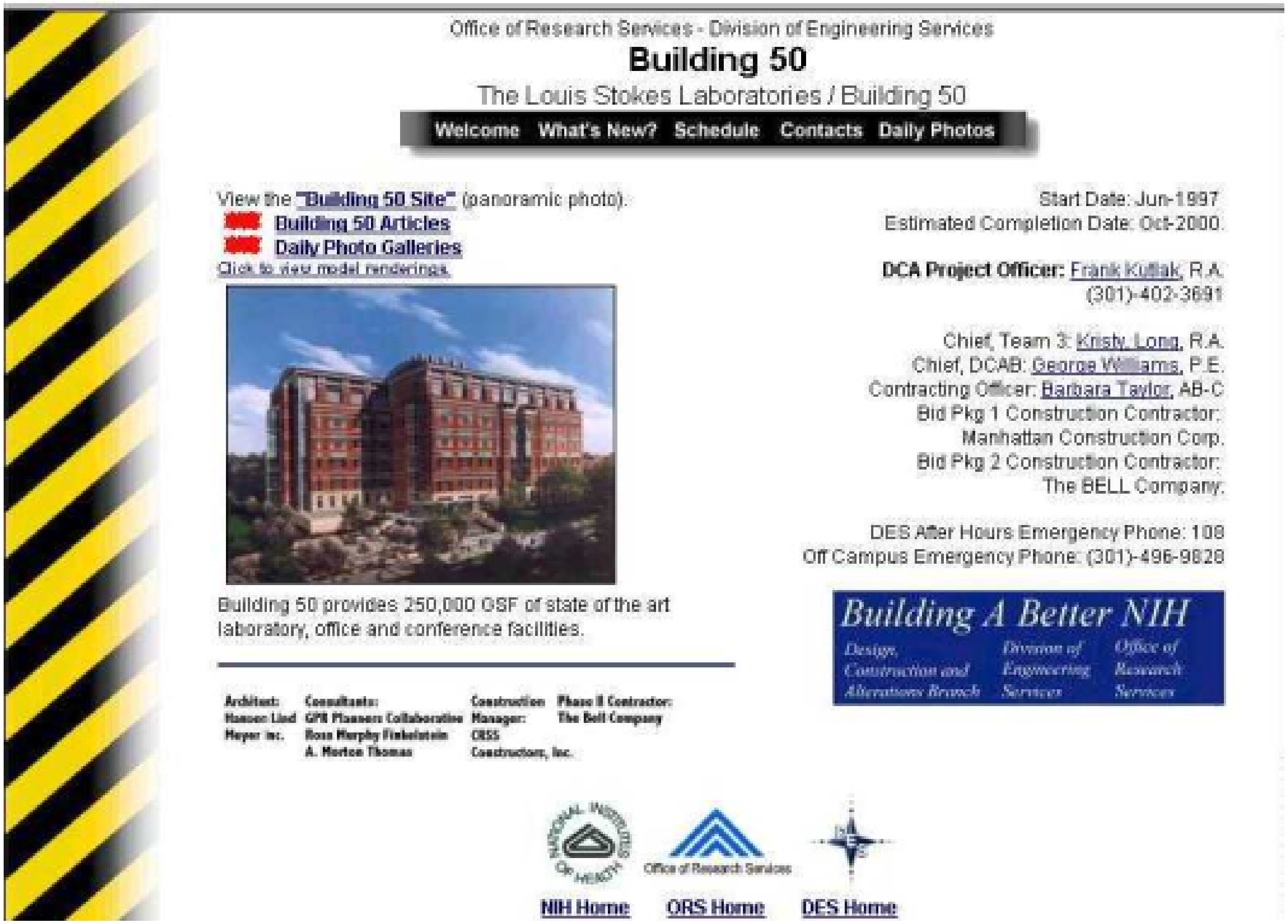
NIH BUILDING 50

Louis Stokes Laboratories / Building 50 Website Address http://des.od.nih.gov/building_50

Features of the Building 50 design including floor plans, renderings, model photos, daily construction photos, hyper links to building 50 "NIH Record" articles, technical articles and a real time view of the construction site can be viewed on the Building 50 website



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Other Research Laboratory Design Websites

- **NIH Office of Research Services**

Office of Research Services
Serving the NIH Community
ORS

  - **Main webpage - http://www.nih.gov/od/ors for all ORS services**
  - **ORS Planning Policy & Guidelines - http://des.od.nih.gov/ndgp.htm Choose "NIH Design Policy and Guidelines" for design guidelines for Clinical Center, Research Laboratory, Vivarium or Reference Materials Volumes**

CLINICAL CENTER
NIH DESIGN POLICY AND GUIDELINES

RESEARCH LABORATORY
NIH DESIGN POLICY AND GUIDELINES

VIVARIUM
NIH DESIGN POLICY AND GUIDELINES

- **Lawrence Berkeley National Laboratory**
  - **"A Design Guide for Energy Efficient Research Laboratories"**
    http://ateam.lbl.gov/design-guide

- **Federal Energy Management Program**
  FEMP Main webpage -
  http://www.eren.doe.gov/femp/femp.html

Energy Efficiency and Renewable Energy Network (EREN) U.S. Department of Energy

FEMP FEDERAL ENERGY MANAGEMENT PROGRAM

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Executive Order 13123 - Greening the Government Through Efficient Energy Management, issued June 8, 1999

- **This is a new broad directive issued by President Clinton that requires the Federal Government to improve it's energy management practices.**
- **Under "Part 2 Goals" , Energy Efficiency Improvement Goals - Sec. 203 is a specific section on "Industrial and Laboratory Facilities"**
- **Sec. 203 "*Industrial and Laboratory Facilities*, Through life cycle cost effective measures, each agency shall reduce energy consumption per square foot, per unit of production, or per other unit as applicable by 20 percent by 2005 and 25 percent by 2010 relative to 1990. No facilities will be exempt from these goals unless they meet new criteria for exemptions, as issued by DOE".**
- **The Louis Stokes Laboratories with it's energy efficient systems that will save over 40% of the energy of previous NIH laboratory facilities, will more than double this goal and will significantly contribute to the overall goals of NIH and The Department of Health and Human Services.**

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Institutes in The Louis Stokes Laboratories / Building 50

National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health

NATIONAL INSTITUTE OF ARTHRITIS AND MUSCULOSKELETAL AND SKIN DISEASES
NIAMS

The National Heart, Lung, and Blood Institute

NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES
NATIONAL INSTITUTES OF HEALTH
NIAID

NATIONAL INSTITUTES OF HEALTH

NATIONAL CANCER INSTITUTE®

National Institute on Deafness and Other Communication Disorders
N I D C D